

UNITED STATES AIR FORCE RESEARCH LABORATORY

DEVELOPING A RAPID SITUATION
AWARENESS: UNDERSTANDING THE
CHALLENGES FACED BY FIRST
RESPONDERS TO BIOLOGICAL AND
CHEMICAL EVENTS

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FOR THE COMMANDER


MARIS M. VIKMANIS
Chief, Crew System Interface Division
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Introduction

The Problem and Opportunity

Large-scale terrorist attacks on United States soil were considered possible, even likely. They are now reality. The current state of the world means that agencies across the globe must prepare for disaster like never before. The question is no longer if, but when and what. When will the next incident take place? What will be the nature of that incident? Although these are difficult questions to answer prior to the onslaught of an incident, organizations are beginning to address the need for preparation, training, and response to whatever attacks may occur.

Two likely events are biological and/or chemical attacks within the U.S. The development, usage, and testing of biological and chemical weapons has been monitored and studied by government agencies, researchers, and legislators for several decades. The threat of employing such weapons continues to grow as the world has witnessed both state and non-state actors utilize such weapons. After the northern Iraqi town of Halabja fell to Kurdish Troops in 1988, Saddam Hussein ordered chemical attacks on the civilian population that included such substances as mustard gas, sarin, tabun, and VX nerve agents (Gosden, 1998). There have also been instances of organizations and individuals planning and carrying out large-scale assaults. Advances in science and technology have created availability of knowledge and resources needed to manufacture and deliver weapons of mass destruction (WMDs). In 1995, the Japanese cult Aum Shinrikyo released sarin nerve gas throughout the Tokyo subway system, whereby 12 deaths and 3800 injuries were reported (Olsen, 1999). Most experts agree that an increase in these types of attacks are inevitable and that the U.S. is currently ill prepared not only to respond to such attacks but also to prevent and defend from them.

In a recent survey, more than seven out of ten U.S. mayors expressed "very high concern" or "high concern" about chemical (73%) and biological (71%) threats (U. S. Conference of Mayors, n.d.). This fear far outpaced that of crime, any nuclear event, or cyberthreats. Since the September 11, 2001, terrorist strike on the World Trade Center and the Pentagon, national concern has become elevated for the vulnerability of our national, state, and local infrastructures to a broad range of terrorist capabilities and weapons of mass destruction.

Responding to large-scale outbreaks and neutralizing the subsequent effects of these attacks will require the mobilization of a network of responders. Those involved will range from local, state, and national workers and will involve civilian, government, military, public health representatives, private healthcare providers, and emergency responders. Understanding the problem and mobilizing agents to begin responding is not only important for saving lives, but also to reduce and minimize other effects such as public panic, widespread fear, and reduced confidence in government. According to the Center for Disease Control (CDC), early detection and control of biological or chemical attacks depends on a strong and flexible public health system at the local, state and federal levels (Centers for Disease Control and Prevention, 2002, April). This report documents findings regarding response to these events, the current state of local preparedness, and recommendations for future work to dramatically increase the effectiveness of response.

Phase I Technical Objectives

Klein Associates' primary objective of this Phase I effort was to understand the critical elements of recognizing and responding to biological or chemical terrorism attacks. The specific technical objectives to accomplish during the effort were to develop an understanding of how first responders in such incidents develop awareness in these complex, dynamic situations; understand the development and operation of a sustainable command post responsible for the mitigation of the event; and document the critical cues, range of factors, and strategies necessary to develop an accurate assessment of the situation and respond to such events. This report will describe our findings during the various phases of the project, including research and preparation; data collection and analysis from Cognitive Task Analysis (CTA) interviews and observations from regional bioterrorism exercises; and recommendations and opportunities for future research in biological and chemical terrorism incidents.

Background

Within our research area the project team focused on the development of situation awareness of first responders in a biological or chemical terrorist incident. Research activities included reviewing available literature in this domain, including case studies of terrorists who had acquired or used chemical weapons. Numerous online articles and websites on Homeland Security issues and policy, articles on the establishment of Civil Support teams, a first responder handbook for attending to biological or chemical incidents, and a book on the threat of weapons of mass destruction provided valuable guidance and direction for the project. These activities were undertaken as a familiarization exercise to survey the research completed in this domain and aid our understanding of current levels of preparedness for such incidents.

Overview of Biological and Chemical Attacks

One of the major influences on the direction of our research in this Phase I stemmed from the literature describing the difference in first response to various kinds of terrorist incidents. At first glance, chemical and biological events might appear similar, as both will create a great deal of panic, disease, and death. Yet, the initial response to these incidents must be quite different. Experts in the field make a distinction between the diagnosis and subsequent ramifications of a *biological* versus a *chemical* attack. *Biological* attacks differ from *chemical* attacks in the method of the dissemination of the harmful agent that is released. It is the nature of the agent at work, the dissemination method, and subsequent detection that influences which personnel are considered the "first responders" on the scene of the attack.

Biological terrorism agents fit in three basic categories: bacteria, viruses, and toxins. Examples of biological agents include the recent wave of anthrax spores sent via personal correspondence through the U.S. postal system. Chemical terrorism involves four categories of agents: choking and incapacitating agents, blood agents, blister agents, and nerve agents. Examples of chemical weapons include the sarin nerve agents used by both the Iraqi government and the Aum Shinrikyo organization.

Sometimes the phrases *overt attack* and *covert attack* are used in conjunction with the descriptor of the agent at work. Chemical attacks are likely to be *overt*: the effects of chemical agents absorbed through inhalation or by absorption through the skin are usually immediate and obvious. Overt attacks elicit immediate response from police, and fire and EMS personnel. In fact, many efforts in strategic planning and training have been directed toward crisis management after an overt attack, such as a known chemical release or explosion. First responders include fire, police, and emergency rescue workers, with the FBI assuming lead responsibility for the event. These responders are tasked with stabilizing the situation, dealing with casualties, decontaminating the area, and collecting evidence for identification of a perpetrator.

In contrast, attacks from biological agents are more likely to be *covert* and present an entirely different scenario. They present distinct challenges and require an additional dimension of emergency planning that involves the public health infrastructure (CDC, 2000). According to testimony given before the U.S. Senate Subcommittee on Public Health (Henderson, 1999, March 25), a biological weapons release would be silent and almost certainly undetected. An aerosol cloud would be invisible, odorless, and tasteless. It would behave much like a gas in penetrating invisible areas. In incidents of biological weapons usage, recognition and response to an attack would not begin until days or weeks after the initial release. Then, patients would begin appearing in emergency rooms and physicians' offices with symptoms of a strange disease that few physicians had ever seen. Preparedness for these attacks lies in educating healthcare providers to recognize the symptoms of such exposures as victims begin presenting in local health clinics, doctors' offices, and hospitals. Fortunately, these biological weapons are not easy to obtain and hard to weaponize. However, the consequences are so grave that the possibilities cannot be ignored.

Implications for First Responders

The major difference between these overt and covert attacks, or biological and chemical incidents, is whether victims begin to exhibit illness immediately or if there is an incubation period and victims begin to show up at the hospital or clinics presenting with certain symptoms. In the former case, there would be no sudden alarm for first responders that dictates action within minutes or hours. In fact, the first responders would not be fire and law enforcement staff but public health and medical personnel.

Figure 1 illustrates a critical point with regard to first responders. A chemical attack is an overt attack. The number of casualties following an attack would be devastating, but would decline as the mitigation of the event continued. The first responders are simply the first trained individuals on the scene. These responders might be fire, police, or emergency medical service personnel. The development of their situation awareness will likely be quick; most of the data will be immediately available to them. The sicknesses being exhibited, the method used to disperse the chemicals, and the number of individuals exposed will likely be available soon after the onset of the incident.

The data involving a biological attack are far more difficult to acquire. It is likely that individuals will begin to show symptoms days or weeks after the initial biological attack, and the

casualties would rise days and weeks after the release of the agent. Data will be distributed as individuals present themselves at various medical facilities around the country. It will be difficult to determine the method of dispersement or the number of individuals exposed. Therefore, the development of situation awareness will be quite difficult for a biological event.

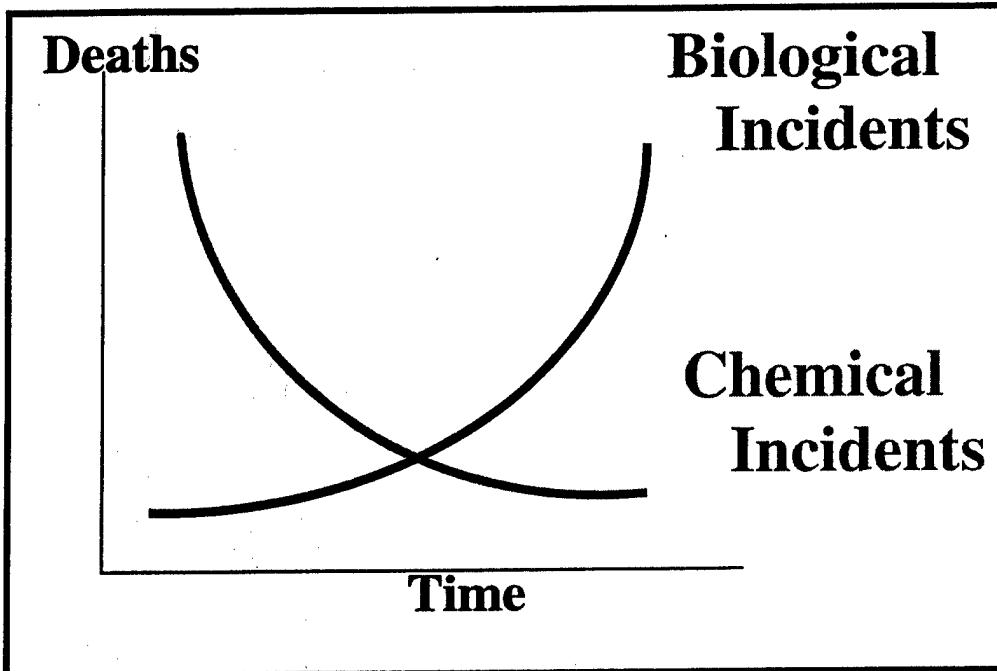


Figure 1. Biological vs. chemical attacks in terms of deaths over time.

This points to the difficulty in determining exactly who will be the first responders to these types of events. Therefore, early in the project we determined that identifying a single "type" of first responder was not realistic. We simply could not target one group of people and attempt to help them be better responders. We determined that we needed to understand the overall response "group" (made up of various "types" of responders) to see where we could make recommendations to improve the process of first response. It is with this perspective that we conducted our interviews and observations.

Cognitive Task Analysis

Our cognitive task analysis (CTA) included interviews with local health officials and federal agents who were attempting to establish a department to support a first response. We also observed local exercises that included county and public service officials (police, fire, EMS), health commissioners, Federal Bureau of Investigation (FBI) personnel, staff members from local hospitals, elected officials, and others. This CTA provided us with a picture of how a response to a biological and/or chemical event would take place. We used observational techniques to understand how teams form and function in a command and control environment created to respond to a biological attack. In addition, interviews with local health officials who were critical in dealing with several anthrax cases within the past 12 months also informed our understanding of first response. We collected numerous lessons learned, processes established, and ideas on work that is yet to be done.

Method

Klein Associates' methods for conducting CTA have evolved from the study of Naturalistic Decision Making (NDM), a field of study pioneered at Klein Associates. NDM is the study of how people make decisions under conditions of stress, time pressure, high consequences, and ambiguity. The NDM approach is particularly applicable to this project because the models of decision making that have emerged from this endeavor place a large emphasis on the situation assessment skills of the decision maker and thus on the resulting situation awareness (SA). Without good SA, the first responder is not in a position to utilize his or her expertise in responding to the terrorist event.

CTA comprises a series of techniques for knowledge elicitation and knowledge representation. We have found that no single method works well in all cases, but that the methods must be adapted to suit the needs of each domain. The methods that are most effective in each domain depend on the characteristics of the task, the characteristics of the subject matter experts in the field, and the conditions under which they must operate. To aid our understanding of response to biological and chemical attacks, we used the Critical Decision Method (CDM) interview technique (Hoffman, Crandall, & Shadbolt, 1998). CDM interviews take four flexible sweeps through an account of a specific incident: incident identification, timeline verification, deepening, and hypothetical questions. Through probing around the specific context of the episode, this knowledge elicitation technique reveals how particular aspects and events in the environment impel the decision maker to action. CDM allowed us to collect personal incidents that contained valuable insights, cues, strategies, and factors that the experienced professionals used to respond to potential attacks.

*Research Findings**CTA Interviews with Federal Officials*

We interviewed two individuals from the Pentagon who are members of the Homeland Security Team. These individuals are on a team that is attempting to establish national and local guidelines regarding the response to these types of events. Our CTA focused on their current efforts, the difficulties they were having in developing these guidelines, and what they believed the future held for responding to biological and/or chemical events.

In these interviews, a generic process was discussed that also appears in the *First Responder Chem-Bio Handbook* (Venzke, 1998). That process is as follows:

1. Scene Assessment and Control
 - a. Initial Assessment
 - b. Scene Management
2. Indicators of Chem-Bio Attack
3. Personal Protective Equipment
4. Protective Levels

The following paragraphs describe the stages of this process in more detail.

1. Scene Assessment and Control

Assessment and control specifically deal with the period of time immediately following the onset of an incident. What is the nature of the event? How can the impact be minimized? What might happen next? It is here that we found the least amount of vision and, as one might predict, the least amount of research and data. Said differently, this is an area in need of attention. This is the most critical time in the mitigation of an event. Yet, the guidelines being established, as well as those in the handbook, are quite vague. There is little guidance for a local municipality to use to help them establish a command center, less so regarding the individuals who should be in that command post. Certainly, different events call for different specialties to be represented in the first responder wave. Yet, these topics are not being considered (First Responders Chem-Bio handbook, pg. A-1/2-10).

2. Indicators of Chem-Bio Attack

The guidelines here are slightly more precise. The goal of this step in the process is to make an assessment as to the type of incident or attack. What is the chemical or biological agent that is causing the incident? Once that assessment is made, more detailed analysis is performed to determine the exact nature of the attack. It is here that there is a great deal of data available to the responder. Years of medical and military research have provided vast amounts of incidental data. Responders can access images, symptom descriptions, and confirmatory data (i.e., animal deaths, status of insects in area, geographical patterns of affected individuals) via the Internet. As this report is being prepared, several agencies are attempting to make this type of data more readily available. We believe that these efforts will greatly benefit the local individuals who are likely to be those first on the scene (First Responders Chem-Bio handbook, pg. A-2/11-15).

3. Personal Protective Equipment

This step in the process is obvious. The responders must protect themselves from the elements that are causing the event. Again, there is a great deal of research and attention paid to this area. With the possible exception of the late 1950s and early 1960s, Personal Protective Equipment (PPE) is more available to the general public than ever before. Today's equipment provides the wearer with exceptional protection for long periods of time. Guidelines exist to aid in determining exactly what type of PPE to wear. These guidelines are based on the data developed in Step 2 above (First Responders Chem-Bio handbook, pg. A-3/16-22).

4. Personal Protection Levels

Personal protection levels address the area of protection of the general public. When should evacuations be ordered? Should areas, and people, be quarantined? This, again, is an area in which a great deal of research has been conducted. Much of the data was generated by the nuclear power industry. Numerous studies of radiological clouds and their drift patterns have

been conducted and shared. We know a great deal about how these clouds move, disperse, dispense, and dissipate (First Responders Chem-Bio handbook, pg. A-4/23-24).

In summary, the interviews with the individuals from Homeland Security provided us with insight into where we are strong in terms of first response and where there is still work to be done. Appendix A provides a representation of some of the information (procured from these interviews) required to make a decision in biological/chemical attacks. These interviews did little, however, to provide us with insight into exactly how first responders developed their situation awareness, how they made initial decisions regarding mitigation of the event, and how they might establish a command post to better serve the public.

CTA with Local Public Health Officials

In the months following the September 11 tragedy, U.S. citizens across the country got their first exposure to biological attacks in the form of letters contaminated with anthrax spores transmitted via the U.S. Postal System. Several casualties were reported due to these attacks. However, a far-reaching effect of the anthrax cases was the widespread fear and public panic instilled in people across the nation. Citizens on the alert for anything that could be deemed "suspicious" ended up overwhelming local and state agencies attempting to research each and every reported incident. According to the experts interviewed, in the State of Ohio alone, over 1200 potential cases of anthrax were reported to the Ohio Department of Health in 2001. The previous year, the state organization had received less than five inquiries on potential attacks.

Klein Associates had the opportunity to interview two representatives from the local county health district. As much as their personal experience allowed, we walked them through real-lived incidents, eliciting the cues for developing situational awareness, the roles of people involved, lessons learned, etc. We focused on the details of the anthrax incidents, including what was difficult and unexpected about the situation they were presented with, the chain of command for decision making, and the flow of information between the first responders. The most salient examples of responding to biological attacks came from their experience.

The SMEs we interviewed described the second and third order consequences from these reported cases. First and foremost, local first responders realized how an anxious and nervous public could quickly overwhelm them and their resources. One large manufacturing plant in the Dayton region had 12 reported incidents alone over the course of several weeks. Police, fire, and health officials and HAZMAT personnel were responding to each and every call, which pulled resources and personnel away from other events. At the health department, the SMEs each set up a chain of people to relieve them. After a few weeks of non-stop responses, they learned that officials could not be on call all the time.

The consequences of responding to such attacks were not contained at the local level. Many samples statewide were sent to the Ohio Department of Health (ODH) laboratory in Columbus for testing. The first sample that our SMEs sent for testing took four hours to confirm the nature of the substance. The second one took four days. During the onslaught of the anthrax cases, the lab only had three microbiologists on staff and they were working around the clock for weeks. The backup at the lab also has implications for medicating those infected. Confirmation

from the lab is important before beginning any medications, but the longer it takes to confirm the substance the more danger the victims face.

To control the volume of samples being sent for testing, the ODH rapidly developed policies on what they would accept in a sample. They determined that the samples had to be deemed a credible threat by law enforcement or else the lab would charge a fee for running each test. While this was necessary for ODH to establish, the burden of assessing a "credible" threat now rested with local officials. The true and actual first responders in such incidents are fire and police, with the fire chief typically as the lead command for the incident. When there has been human contact with a substance or spill, the health department is called in. Our SMEs reported difficulty in deciding amongst the agencies responding who would be in charge of determining the credibility of the threat. The fire chief is in charge of the operation from the health department's standpoint, but from the fire department's perspective, the health personnel hold the expertise in the matter and should make the decision.

These examples from the recent anthrax scares both locally and across the country demonstrate the need to improve the local and state first responder infrastructures. Procedures and protocols need to be developed within functional domains such as healthcare and law enforcement just to respond to potential incidents effectively. It is simply not enough anymore to expect that various first response organizations will be able to adapt to a novel situation such as a biological attack. Furthermore, these organizations must create joint protocols, whether through the establishment of an emergency command center or response organization. Future first responders need to have a clear understanding of roles, functions, and responsibilities of other professionals in order to prepare for events for which to date there has been no precedent or lessons learned established.

Conference on Reducing Biological Threat and Countering Terrorism

Two members of our research team attended BTR 2002, the Second Annual Conference on the Unified Science and Technology for Reducing Biological Threats and Countering Terrorism, March 14-15, 2002 in Albuquerque, New Mexico. The University of New Mexico, University of Texas at Austin, Los Alamos National Laboratories, and Sandia National Laboratories sponsored the conference. The program for this conference, featuring speakers from government, industry, and academia, presented topics for discussion in three areas of homeland security:

- 1) Sensing of the environment and validation of an attack;
- 2) Power of information and situational awareness: transitioning from information to command and control;
- 3) Human-centric technology: keeping a pulse on the operational community.

Attendance at this conference provided us with a tremendous amount of information regarding the current state of research in the area. There is much work being done to help groups of local responders acquire information, disseminate that information, and reach conclusions. The problem is that much of the dissemination and conclusion generation is taking far too long to be considered practical. The attendees understood this issue, and much discussion was held

regarding this topic. This conference also generated a long list of questions, which helped guide the rest of our data collection.

We learned that there is a great deal of effort in two distinct areas: physical detection devices and post-event analysis tools. The physical detection devices are sensors that detect the presence of potential biological or chemical agents. Obviously, these are very important devices. The post-event analysis tools provide researchers with the ability to put disease data into a computer program and then develop an assessment of an event that has already taken place. The development of these tools is important, though less obvious than the sensors. If these computer simulation tools provide the researcher with various representations regarding disease reports, that researcher can, over time, determine whether a disease pattern was significant or not. Was there an attempt to disease a population or was the event simply natural in origin and dispersement? If easy to use, powerful tools can be developed to parse through large amounts of data to help the researcher make these kinds of decisions. The next step would be to provide these tools for use by doctors and other local health professionals to make those same predictions in real time. This is far more critical in the event of a biological incident in which rapid detection of common symptoms and diagnoses are critical to the successful mitigation of such an event.

Observations from Regional Biological Terrorism Exercises

Klein Associates' researchers were invited to participate in two regional bioterrorism exercises as guests of the Greene County Combined Health District (GCCHD). Decision makers and responders from agencies and associations in counties across Southwest Ohio (Fire Department, Law Enforcement, Public Health, etc.), as well as representatives from State and Federal agencies (ODH, FBI, etc.) were also invited to attend. Participation in the exercise was voluntary, and players came as their availability allowed. The exercises simulated an outbreak of the plague starting in a concentrated public area (a rock concert at Wright State University in the first exercise and King's Island Amusement Park in the second). Participants were presented with situation updates then broken into county or functional area caucuses to discuss their plans for response. Our researchers actually filled the roles of exercise evaluators during each simulation exercise. We were responsible for commenting on how various participants across counties and professional functional areas (law enforcement, government officials, health department, hospital networks, etc.) worked together to solve the problems associated with the simulated biological attack. We used provided checklists of issues and expected actions to evaluate the exercise participants.

These guides reflect key behaviors that effective teams engage in when working towards a goal. We also prepared exercise observational guides designed to focus our observations at the exercises. At a high level, there were two main issues for which we wanted to collect data. First, we wanted to observe how the exercise participants tackled the initial identification of the problem: What happened in the simulated event? How did decision makers figure out the cause and extent of the event? Who should be involved as responders? Secondly, we were interested in the mobilization of subsequent chains of responders. Was there evidence of a sustainable command post being formed? Who was called in to the scene? Who was in charge and where did people go for information? How did coordination work or not work across agencies? How did responders maintain their situation awareness and adapt to changing circumstances/demands

throughout the event? How did they minimize the impact of the event and communicate information to the public?

We utilized the Advanced Team Decision Making (ATDM) Model (Zsambok, Klein, Kyne, & Klinger, 1992) as the basis for analyzing our exercise observations. This model contains 10 behaviors critical to a team's success. Developed within a project for the Army, the model is particularly applicable for strategic and planning teams. The model has been evaluated at several locations within the military (i.e., Army War College and Industrial College of the Armed Forces) and has been applied to wide variety of domains (Klinger & Klein, 1999).

The ATDM model is organized around three critical team elements (see Figure 2):

- Team Identity
- Team Self Monitoring
- Team Conceptual Level

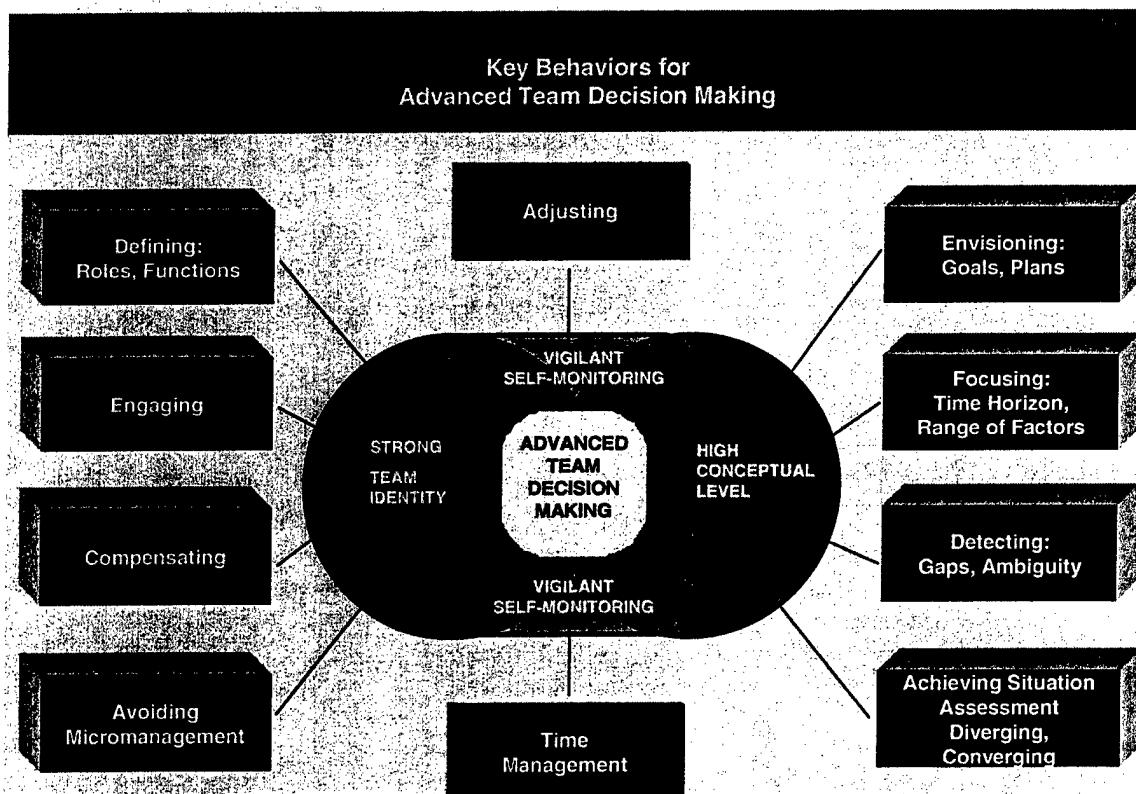


Figure 2. ATDM model.

The ATDM model is not an all-inclusive model of how teams perform. Instead, it provides guidance as to the behaviors that matter most. Successful teams exhibit the 10 behaviors identified in the model, and less successful teams do not exhibit one or more of those behaviors. This model, therefore, is a valuable tool for assessing team performance. Using it as a framework, we are able to pinpoint where teams excelled and where they needed improvement. The following sections discuss our observations from the exercises that relate to the concepts of

Team Identity, Team Self Monitoring, and Team Conceptual Level. [These observations have also been shared with GCCHD.]

Team Identity. Team Identity illustrates the extent to which members consider the team an independent unit and operate from that perspective while engaged in their tasks. Advanced teams are able to capitalize on the power of the group's shared expertise and collective approach to the goal, while weaker teams are forced to rely on members' own individual skills. There are several behaviors that provide insight into how well a team knows and understands itself. This includes how well team members know their own role and function and how well they understand the roles and functions of those around them. Having this understanding allows teams to plan, anticipate, and react to changing circumstances. Team identity also includes how well the individuals compensate for each other in order to help the team reach its goals, as well as how well they engage in the activities the team undertakes towards its goals. The exercises provided an opportunity to gather evidence of participants exhibiting team identity behaviors at various levels of effectiveness.

One of the goals for the exercises was to bring together different functional areas in a collaborative environment, thereby creating an opportunity for cross-exchange of information for the purposes of responding to the simulated event. Knowing the roles and functions of those involved enables team members to create a team identity whereby each member contributes expertise, energy, and attention towards accomplishing tasks for the larger goal. Examples of strong team identity were observed when two different counties both decided to set up a command structure for the Emergency Operations Center (EOC). One county set up their EOC and then recognized the need to train replacements in this command structure. In another county, the fire chief assumed command for the emergency response coordination and the health commissioner was designated as second in command. The health commissioner was deemed a crucial player because he had access to the Ohio Health Alert Network, a system through the Ohio Department of Health that would provide valuable statewide updates on health issues and events. This EOC also created sub-teams such as a communications group to work on establishing mechanisms for sharing information both within the EOC and to the public. Both county-level EOCs created an authority of command early on in the simulation as a way to leverage the expertise represented in the committee and to systematically address the volume of issues surrounding the mitigation of the event. However, there were other groups that neglected to appoint specific people for key leadership roles, relying instead on the assumption that outstanding issues would be resolved by this stage in the event.

Team identity is also fostered through engaging in the work required to reach the team's goals. Signs of disengagement include adopting a passive stance, whereby a person waits to be directed by others, or non-participation during group discussions where the person fails to contribute ideas or reservations about the direction the team is taking. A public health and a medical official dominated one caucus discussion period, conferring mostly with one another unless someone else in the group spoke up. While these team members were very engaged, they did not make concerted efforts to open the discussion back up to the larger group and re-engage their colleagues. One reason for the disengagement may have been because the caucus was very homogenous in its makeup; they had no fire, emergency medical services (EMS) units or law

enforcement personnel represented. The lack of functional area representation may have stymied the exchange of different ideas and perspectives.

Another caucus composed of law enforcement professionals expressed disengagement a different way. While they were engaged in discussions and planning with fellow law enforcement, they relied immensely on other agencies to guide them in their actions and failed to engage with larger teams of various functional areas. For example, the caucus expected to be told specifically by the health commissioner what to do and say with respect to public announcements. They also expected that the hospital would be in communication with them to make their needs and requests known. They believed that both the FBI and the National Guard would have specific protocols as well. Feeling that they could count on these organizations to take the lead, law enforcement settled for the role of pledging their support where needed and when tasked. It appeared that there were very few existing protocols that would enable them to take a proactive rather than reactive role in the case of a bioterrorism attack.

“Compensating,” a behavior important for establishing team identity, is the ability of individuals to step outside of their assigned roles or functions and perform different ones in order to help the team reach its goals. We observed one caucus that never succeeded in adapting and compensating for each other in the event of a novel situation. Team members expressed confusion over who would actually serve as first responders if an actual biological or chemical attack had occurred. While the fire department had the necessary gear to protect their personnel, local law enforcement brought up the fact that police departments have no protective gear available to them. Some situations that could be deemed a potential crime scene but still involve hazardous materials would still precipitate a law enforcement response. Therefore, the police would respond to such an incident, but would be risking injury to its personnel through lack of protective gear. The caucus could not arrive at a decision about who should respond in cases where the cause of the outbreak or spill was unknown. This issue presented as a major stumbling block for emergency and law enforcement officials who need to work together to jointly respond to such events. Although each functional area had working procedures and experiences, in the absence of a shared experience of responding to a biological or chemical attack, these groups were unable to create innovative protocol or procedures.

We did, however, observe instances of counties compensating for other counties in discussions about acquisition of resources and mutual aid agreements. The realization occurred that other counties in the area might be inundated and unable to contribute needed resources. To counter this effect, one county hospital system began arranging mutual aid agreements with local refrigerated trucking companies and funeral homes. Another county was in the process of setting up interstate emergency mutual aid agreements, which would allow them to exchange personnel with Kentucky and Indiana. In these instances, the teams prepared to counter unexpected events that may pull necessary resources away from the crisis at hand.

Team Self Monitoring. Team Self Monitoring includes subtle behaviors that successful teams employ. These behaviors include team adjustment and time management. Successful teams monitor their own process and make adjustments to that process. They provide mechanisms to alter the team member structure to best address the current situation. They understand where expertise lies within a team and provide a process in which that expertise can

be applied to a current situation. Successful teams know how long certain activities should take, thereby providing enough time for careful planning and execution.

Team Self Monitoring is the ability of a team to observe itself in action, to see how well they are using the behaviors associated with Team Identity and Team Conceptual Level. Strong teams are able to not just observe themselves, but also to modify the way they perform when they discover problems. The process is iterative; advanced teams are constantly watching themselves and adjusting their performance, and then they evaluate their changes to see if they have been effective. Teams at a basic level of self-monitoring may decide to make corrections to their performance, but then not monitor to see if the change was effective or fail to implement the change due to time constraints.

The groups we observed seemed to be at this more basic level of self-monitoring, at least in the context of this exercise. Largely due to the nature of the simulation exercises, many groups identified changes that needed to be made, but then did not implement them in the immediate situation. Usually the various groups of players noted the changes that would need to be worked on for the future, then simply moved on to identify more needs. For example, the hospital system team wasn't sure they would be able to support EMS resource needs in the case of a bio-terror emergency and realized that some sort of supply coordination and tracking system was urgently needed, but did specify how they were going to handle this problem in the situation at hand. Likewise, some of the elected officials determined that EOC procedures for dealing with public unrest should be created, but this item was not implemented during the exercise itself, it was merely noted for future consideration.

Advanced teams are also able to effectively manage time so that they are not consumed by deadlines or held up by unfinished sub-tasks. They often create schedules, work steadily, check their progress as they go, re-prioritize as needed, and keep team members informed of changes. On the other hand, less-experienced teams may jump into a task without considering the amount of time it will take to complete. Time management was hard to observe in the teams in this exercise because the nature of the exercise did not demand that they react in a timely fashion. Their response decisions were not dependent on earlier decisions or completion of earlier tasks.

Team Conceptual Level. Team Conceptual Level includes behaviors that provide insight into how successful teams act in concert. Successful teams know how long certain processes take and they consider this time horizon when making decisions and generating courses of action. They know how to diverge and gather opinions and then transition into a convergent mode in order to make a decision and generate a course of action. Successful teams clearly communicate and understand the goals and sub-goals that are critical to their success. All team members understand those goals and their expected contributions to it.

Teams that operate at a high conceptual level are able to articulate their goals and the process the team will use to achieve those goals. All team members need to have a clear idea of what the team is trying to accomplish, including identification of priorities. An example of a high priority identified by a county in the second exercise was the safety of the first responders and the family members of the caregivers. The county recognized the dangerous implications of

losing critical response personnel, whether losing them to concern for their own safety or for the safety of their loved ones.

Team members also need to understand how the team will approach their mission, including who will make certain decisions and when actions will need to be completed. For example, one county discussed utilizing cablevision as a mechanism for broadcasting to the public then immediately decided who would be responsible for implementing the broadcast. Advanced teams often establish checkpoint meetings to review the process or use mental simulation to visualize where the team needs to be in the process by a particular time. Many of the groups we observed established regular checkpoint meetings for key personnel and decision makers and a few engaged in visualizing the future to determine how actions and events would unfold. One team visualized how to have prophylaxis distribution sites set up by the time a definite diagnosis of the outbreak was received.

One common error in teams is *assuming* that members share an understanding instead of actually developing a shared understanding. For example, during the first exercise, the people leading a county-wide discussion did not check with others around the table to make sure they understood or even heard the decisions being made. They did not use specific, concrete language to articulate the team goals and plans. Instead, they only hinted at certain issues, assuming that others at the table would make the mental leap to understanding the implications of their comments. This problem was highlighted during their group reports, when they proceeded to outline decisions "made" that had never been articulated clearly during their group discussion. This same problem appeared during functional area caucuses, when part of a group reported their plans to take certain actions that were misaligned with goals of the rest of their group.

Another problem observed in these exercises was simply not developing a plan or process for making critical decisions. This problem was especially apparent in regard to communication. Many teams identified a need to communicate with other functional areas or federal agencies, but did not specify a plan for how to accomplish this communication. Another example came from one of the functional groups. Late in the development of the scenario, this team declined to identify a person to be "in charge." They relied instead on the assumption that the issue would have "sorted itself out by now." These assumptions of shared awareness and lack of specificity over plans to carry out decisions are potentially disastrous to achieving the goals of the team. The best decisions are worthless if no one knows how or who will carry them out.

Teams that operate at a high conceptual level demonstrate the ability to focus their decision making within an appropriate time span on a relevant breadth of concepts. They are able to accommodate immediate issues as well as future goals and consequences. For example, one team, after assessing their immediate situation, began discussing the possibility of setting up an alternate treatment site should the existing center become contaminated. Teams at a high conceptual level are also sensitive to a wide range of factors in integrating information to make their decisions. For example, in the first exercise, the health department realized that a second round of infections was possible once those they treated were released, but that the business community would be putting pressure on the health department to lift the quarantine. So they decided in advance to refer to national guidelines to support their position to keep the quarantine in place. They also realized that they would need the governor to authorize the closure of

highways or airports, and that trying to enforce quarantine without the National Guard would be putting their local law enforcement in harm's way. They decided to coordinate the timing of the quarantine with the arrival of the National Guard, and in the meantime, continue encouraging the public to stay in the area to receive treatment.

Teams operating at a lower conceptual level often concentrate too much on the present at the neglect of the final goal. Teams at a lower conceptual level may narrow their focus too much, ignoring the range of dimensions, which might impact a situation, or they might try to tackle too wide a scope, effectively paralyzing themselves because they are trying to consider everything. This mistake occurred in one of the county caucuses. The first ten minutes of the caucus was a chaotic, frenzied outpouring by different functional areas that stated what the caucus should be worrying about and considering. The health department and the hospital wanted to share information on patient admittance and signs and symptoms. The law enforcement representatives wanted to immediately talk to the other counties to develop plans for dealing with spread of the disease to other counties. Someone else wanted to discuss the declaration of a countywide emergency. Fortunately for this group, a leader stepped up to take control of the discussion and to help them begin to identify team priorities and articulate courses of action.

Teams with a high conceptual level are able to detect holes or inconsistencies in their team's information base. For example, in one of the exercises, the Red Cross and EMA developed a common list of questions they needed the health department to answer, including whether or not there would be a quarantine. The Red Cross also asked EMA when the National Pharmaceutical Stockpile would be coming in. Once these two organizations began collaborating and sharing information, they learned that the health department did enact quarantine and medicine from the National Stockpile was being sent. EMS and the hospital identified a major inconsistency in their information: EMS typically gets their medical supplies from the hospital, but the hospital had not considered the EMS' resource needs when figuring out their emergency re-supply orders. This discussion highlighted a major ambiguity in the handling of resources between these two organizations, an ambiguity that in the case of a real biological incident could have potentially brought the critical EMS response efforts to a screeching halt.

Some teams we observed failed to seek out important information that was not immediately available to them or ignored information that appeared to be contradictory. For example, one group decided that the best course of action was to convince people to stay at home, but they were unsure of how to recommend this course of action through the media. Unfortunately, they failed to utilize the Public Information Offices to develop a workable plan for making this recommendation. Similarly, the EOC failed to seek information from the health or medical workers on how many people could be inoculated from the national stockpile supplies. These information gaps or ambiguities have the potential to compromise the ultimate quality of a team's work.

Advanced teams seek divergent opinions to sharpen and deepen their understanding and response to a situation. This behavior may include playing "devil's advocate" to attack their own perspective, a tactic that we observed a lot in relation to the media. For example, the health department realized that if they declared a quarantine, the media would ask them why now, after the focal point of the disease breakout (college students at a concert) had already broken up and

gone home to areas around the country. Anticipating this divergent opinion helped the health officials realize that they needed to sharpen their own understanding of the communicability of this disease and better communicate this issue to the media and the public.

Exercise Conclusions. Many researchers, government agencies, administrators, and trainers tied to the first responder community have repeatedly stressed the reality that local organizations will be on their own in the immediate aftermath of a crisis. This exposes the need for hospital systems, emergency response, law enforcement, public health, and government support organizations to improve their infrastructure and preparedness for dealing with such catastrophes. Furthermore, all agencies involved need to build networks and link response support systems at the local level to meet the immediate demands of the crises. We saw evidence that caucuses with cross-representation of functional areas generated richer interactions, discussions, and plans. Each representative was able to offer a different perspective on issues and actions needed because of the event. For example, the discovery that EMA had the authority to call in the Red Cross surprised most members as they learned about the limitations to when and how the Red Cross could respond. In another team, an EMT was able to inform the elected Public Information Officer (PIO) from the health department on the need to coordinate with two divisions of emergency dispatchers. Without this shared knowledge, all the work to create a unified message would have been counteracted by not communicating with all players involved in response. On a larger, more critical scale, these teams were able to identify issues around organizational resources and infrastructure that would have prevented them from effectively responding to the crisis.

In instances where an attack results in problems beyond the management of the local forces, state and federal resources can be called to the scene. However, there is wide consensus that additional resources from state and federal agencies typically take 48-72 hours to mobilize and arrive on station. This leaves the job of responding and gaining control of the incident in the hands of local authorities, typically for the first 2-3 days after a diagnosis of the problem. Local first responders will be in charge of establishing a command and control center with all the relevant players involved in the mitigation of the event. Their ability to recognize, respond, and recover from an attack is critical to saving lives, reducing widespread panic and fear, and controlling civil unrest.

The fact that many local agencies are vital in the response and recovery of an attack stresses the importance for different functional areas to train together. A major conclusion from observing these exercises was that high-performing teams cannot be established without all the major players gathered to tackle the problem. While some groups were actually able to reference and clarify issues with members of other functional areas, others could only assume certain other functional areas would handle certain responsibilities or know how to solve a problem. These groups had automatically identified a role and function for the missing representatives, which may not be an accurate reflection of reality. Furthermore, a powerful lesson for many of the exercise participants was learning about what other functional areas could provide in a crisis. Without a physical presence at the exercise, the missing team members cannot engage, compensate, or share information on assets, procedures, and abilities with other team members. This is not only an artifact of the exercise, but can contribute to negative learning. In a real event, these groups may rely on the decisions and assessments they practiced during the simulation,

which may not be based on actual states of expertise, readiness, and ability. In short, practicing at a table top exercise without the presence of key players could prepare first responders for unrealistic expectations for how to respond in an actual emergency.

Recommendations for Future Research

The CTA conducted within this Phase I project pointed to two major areas in which future work is needed. First, guidelines to help local and state authorities in the establishment of a command post are critical. Police, fire, and EMS personnel at the local level are most likely to be the first responders to a chemical event. Health departments, hospitals, doctors, and urgent care centers are likely to be the first responders to a biological event. These individuals must have guidance based on solid research in order to establish, staff, and operate a command center. The establishment of this command center would dramatically increase the effectiveness of a response to these types of events. Second, we found that the local agencies are eager to take part in training for biological and/or chemical events. We also found that these training events could be dramatically improved by applying what we know about use of simulations and application of learning objectives and learning tools. These recommendations are described in more detail throughout the remainder of this section.

Command Post Guidance

Guidance for the establishment of a biological/chemical command center could be adapted from research already accomplished in other high-stakes environments. The nuclear power industry learned early on that the establishment of a command center is vital to the success of dealing with complex incidents. The accident at Three Mile Island nuclear reactor in March of 1979 was as much a nuclear disaster as it was a command-and-control disaster. There was not a coherent plan to mitigate the event, the public was given contradictory information, and evacuation plans were hastily prepared and incorrect (people were evacuated who should not have been and people who should have been were instructed to stay in their homes). The Nuclear Regulatory Commission recognized this immediately and implemented a standard Emergency Response Organization (ERO). This organization has a logical chain of command, is flexible to accommodate various event types, and provides for guidelines to ensure that the proper personnel are present to deal with different kinds of events. This last point is critical. People who are experts apply that expertise when and where they can best influence the successful mitigation of the event. This type of guidance is even more critical to first responders to biological and chemical events.

First responders to biological and chemical events do not always know what is confronting them. Often, they know that something is wrong but they do not know when, where, or how the problem is progressing. It is in these situations that experts must be assembled and situation awareness must be developed. Experts need to apply their expertise early on in the incident. They are the ones who can sort through the data to determine the cause and effect of the incident. Individuals with expertise and training in dealing with the media and general public must be present at the outset to inform without inciting panic. The same can be said for health officials, crowd control, and evacuation personnel. The list of individuals who are called to

occupy the command post must be flexible. This list must take into consideration the type, the stage, and the severity of the event.

Research is needed to provide guidelines that are generic enough that they can be applied to any and all local municipalities, yet specific enough so that the experts are present at a place where and time when they can make a difference. That research must consult the work that we know exists. Potential areas that will influence these guidelines include:

- Nuclear power industry
- Military command posts
- Command Post of the Future projects
- Disaster Relief Command Posts
- Crowd Control/Riot Control Incident Response Teams

Training

Applying what we already know about the use of simulations in team training could significantly improve the training of individuals who are likely to be first responders to a biological/chemical event. Over the last decade, the development of training simulations has received a great deal of attention in part because the international accessibility of the Internet has dramatically increased the ability to economically dispense this type of training to a wide audience. Internet-based simulations are beneficial to this particular environment because biological/chemical events demand the interaction of people from local, state, and federal offices. Distributed training tools can more easily bring these different levels of responders together.

The engine that drives any training exercise of this type is the scenario itself. It is what shapes all discussion and learning. The key will be to develop scenarios that stimulate decision making, situation awareness development, course of action selection, and problem solving. A well-crafted scenario not only contains the critical elements for learning (i.e., incorporates specific items that address a set of identified learning objectives) but it also must have the appropriate level of cognitive fidelity. A scenario rich in cognitive fidelity provides opportunities for participants to make decisions under time pressure, provides the amount of information that one would expect if the event were real, contains the right amount of uncertainty, relies on players to make judgments regarding their development of a situation assessment, and requires them to make decisions regarding courses of action. That scenario must be flexible enough to allow participants to take multiple courses of action. Similarly, a repository of events that could take place late in a scenario can be developed in order to demonstrate how decisions made early in the exercise impact subsequent developments in the situation. We believe that the development of distributed training tools would dramatically increase the level of preparedness and the efficiency of response in communities across the country.

Combining the development of command post guidance and simulation-based training would best prepare first responders for that day when their training and practice is put to the test. Simulations could be developed that test the guidelines for establishing a command post. Lessons

could be learned during structured practice instead of during a real event. Mistakes can be made and corrected without the loss of life.

Conclusions

The CTA conducted during this effort provided insight into the current state of first responders to a biological or chemical event. It is clear that this has become a priority for the U.S. and will continue to be so for years to come. What is needed is the development of sound principles to guide the individuals who are responding to these types of events. There is no need to reinvent the wheel here. A great deal of the work has already been done within other industries. The nuclear power industry, for example, has spent millions of dollars to develop an Emergency Response Organization. The U.S. military has studied the impact of command centers on command, control, communications, and collaboration. This work cannot be discounted and should provide the foundation upon which to build solid guidelines to aid the first responder.

As the U.S. continues to prepare for a possible attack, training first responders must become a priority. It is these responders that can muffle or amplify an event. The first few moments of response are the most critical, and training must focus on the individuals who will be tasked with first response. Again, there is a great deal of prior research and application that can be applied here. We know a great deal about how to utilize the Internet for training. We understand how to develop simulations that train the skills and behaviors that matter. We have developed scenarios that require decision making, that train individuals in how to deal with uncertainty, that provide guidance in how to develop and maintain a situation awareness, and that provide for an evaluation of selected courses of action. This work must be applied to this problem. The result would be an Internet-based training program that would be used by responders that are distributed within and across response boundaries. Municipalities could share lessons learned and success stories.

To summarize, we are naïve to believe that there will never be a biological or chemical attack on U.S. soil. We should prepare with the belief that this type of attack is imminent. It is this realization that must result in an increase in the attention paid to the support of first responders. The efficiency of these responders is the critical element in the successful mitigation of an event. Their actions in the first few moments will either save lives or spread disaster. Currently, the programs that support these individuals are lacking. Better guidelines for response are necessary. These responders must know how to establish a command post in which expertise is in the right place at the right time. Training tools need to be developed that place these responders in realistic situations, forcing them to make decisions, generate and maintain their situation awareness, and develop courses of action. These training tools should provide for a sharing of lessons between municipalities. At best, this training would reside on the Internet, providing low-cost, highly effective training to a wide audience. At a minimum, this training would be table-top simulations that adequately test and train these critical personnel. Failure to adequately support first responders plays into the hands of those who perpetrate the event. If first responders are ill-prepared the event will be far more catastrophic. If well-prepared responders are on the scene, lives will be saved, property salvaged, and our way of life preserved.

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Appendix A. Decision Requirements in Biological and Chemical Attacks

Decisions	Why Difficult	Strategies	Errors
Determine the best access to scene	<ul style="list-style-type: none"> • Unsure of incident type • Unsure of incident severity 	<ul style="list-style-type: none"> • Approach from upwind 	<ul style="list-style-type: none"> • Emergency overtakes using caution in response
Determine who should be notified	<ul style="list-style-type: none"> • Little guidance exists regarding matching incident type and responders • Automated alert systems may not be developed or may be inaccessible due to attack 	<ul style="list-style-type: none"> • Notify supervisor • If a biological or chemical agent is known, notify ODH 	<ul style="list-style-type: none"> • Expertise is not applied adequately to the incident • Too many people are called • Too much reliance on police and fire to handle events for which they aren't trained
Select appropriate Personal Protective Equipment (PPE)	<ul style="list-style-type: none"> • Unsure of incident type • Unsure of incident severity 	<ul style="list-style-type: none"> • Evaluate supply of PPEs and match with number of responders • Always over protect 	<ul style="list-style-type: none"> • Fail to understand secondary threats and PPE does not match those threats • Overprotection can dramatically slow down effort as additional supplies are delivered
Determine who should be in command post*	<ul style="list-style-type: none"> • Unsure of incident type • Unsure of incident severity 	<ul style="list-style-type: none"> • Bring in experts for each sub-element of an incident (health, medical, police, traffic control, evacuation, media relations, etc.) 	<ul style="list-style-type: none"> • Expertise needed is not present in command center • Too many people are present to increase likelihood that expertise is present

Decisions	Why Difficult	Strategies	Errors
Determine how best to protect public	<ul style="list-style-type: none"> • Unsure of incident type • Unsure of incident severity • Public panic • Unsure of how incident might spread 	<ul style="list-style-type: none"> • Evacuation from prime area • Call in National Guard and other resources to assist • Use media to inform • Establish exit routes 	<ul style="list-style-type: none"> • Misidentify propagation of incident or disease • Overflow exit routes • Fail to protect properties in area • Rely on media to provide accurate information to public
Determine how to prophylaxis public	<ul style="list-style-type: none"> • The public will demand medicine • There may not be enough medication for everyone in the region 	<ul style="list-style-type: none"> • Begin with concentric circles-prophylaxis those closest to the event and their families first 	<ul style="list-style-type: none"> • Administering inoculations to part but not all of the Emergency Operations Committee (EOC) can divide the team • Not administering medication to families of first responders can diminish their desire to continue responding to the scene (they will want to protect their families).

* This was not identified by any of the interviewees although we believe this is an important element to the successful mitigation of any incident.